ABSTRACT FROM THE BOOK OF ABSTRACTS FOR:

25TH ANNUAL MEETING AND SYMPOSIUM OF THE
DESERT TORTOISE COUNCIL
The Orleans, Las Vegas, Nevada
April 20-23, 2000

Tortoise Health and Elemental Chemistry of Forage Plants from Desert Tortoise Habitat between the Rand Mining District and the Desert Tortoise Natural Area, California

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The chemistry of plants, including any surficial dust coatings on the above-ground parts, generally reflects the chemistry of the immediate area where a given plant grows. The desert tortoise (*Gopherus agassizii*), a threatened species, relies mostly on annual and herbaceous perennial plants and cacti for nourishment. Necropsies of ill, dying, or recently dead tortoises have revealed elevated levels of one or more potentially toxic elements (As, Ba, Cd, Cr, Hg, Ni, Pb, or V) in the kidneys or livers as compared with control animals (Jacobson et al. 1991, Homer et al. 1994, Homer et al. 1996). Ingestion of plants with unusually high concentrations of these and possibly other elements may thus influence tortoise health.

During 1998 and 1999, we collected one or more samples of the above-ground parts of 32 different plant species known to be key desert tortoise forage. These samples were from 31 sites along a transect between the Rand mining district and the Desert Tortoise Research Natural Area (DTNA), in the western part of the Mojave Desert of southeastern California. These plants included native herbaceous species, perennial grasses, annual herbs, and cacti, as well as samples of alien annual grasses and forbs. The samples were from relatively pristine areas, as well as from areas contaminated by mine waste and dust derived from this waste--both of which may contain elevated concentrations of elements such as As, Sb, and W. Inasmuch as tortoises eat material in its natural condition, the samples were prepared without washing, and the dried plant material was analyzed for as many as 35 elements (Ag, As, Au, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, Hg, Ir, K, La, Lu, Mo, Na, Nd, Ni, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, U, W, Yb, and Zn) by neutron activation analysis. To provide a context to the plant analyses, we also collected and analyzed samples of rock (20 sites), soil (52 sites), and unconsolidated stream alluvium (19 sites) from the same area.

Both physical and chemical environments in tortoise habitats can influence plant chemistry. Physical environments include areas of rock outcrop, outwash pediment surfaces and their soils, and washes with active sediment and near-surface groundwater. In areas without mineral deposits, the local chemical differences between these three physical environments are generally minor. However, in mineralized areas, the chemical differences between these environments may vary

more widely. As an example, a comparison of analyses of soil and sediment samples from the study area suggests that some elements (As, Au, Pb, Sb) tend to be slightly more concentrated in active wash sediment and some (Cd, Hg) more concentrated in soil. Others (Cu, Cr, Fe, La, Mn, Mo, Zn) show no obvious chemical differences between these two environments. Additionally, near-surface water (and its chemical content) tends to be more available in washes and therefore to plants growing in washes. Thus, the physical environments in habitats may have an effect on element concentrations in plants by tortoises.

Chemical environments are largely influenced by local geology (rock chemistry). Each rock type has a characteristic but variable chemical content. The chemistry of different rock units is commonly reflected in the chemistry of the overlying soils and often of the plants growing in these soils. Unusually high but localized chemical concentrations in rocks may constitute a mineral deposit. In the Rand district, the deposits are enriched in elements such as Ag, As, Au, Sb, and W. Anthropogenic activity related to mining of the mineral deposits may additionally increase the concentrations of the elements in nearby soils and sediments. Anomalous distributions of these elements in the study area clearly delineate the natural and anthropogenic effects of the mineral deposits on soils and plants.

Wind-borne dust is another factor that may affect the chemical content of plants consumed by tortoises. By comparing the relative distributions and concentrations levels of various elements, particularly in samples of soils and plants, we were able to determine which plant samples were probably contaminated by this process. The distributions of anomalous deposit-related elements in soil and plants, especially those of As, show an area of contamination associated with the Rand mining district that extends to the southwest as much as 18 km from the center of the district, to within about 7 km of the northern boundary of the Desert Tortoise Research Natural Area. The extent of the contamination in other directions was not completely defined. The anomaly for As in plants is more extensive than that seen for As in soils, emphasizing the effects of wind-borne contamination.

All plants have normal nutritional chemical needs for their proper growth. However, for reasons not clearly understood, some plant species tend to accumulate specific elements to concentration levels well above what is needed for normal growth. This process could have important consequences for tortoise health. Examples of accumulator plants found in arid areas include *Stanley pinnata*, which accumulates Se, and various species of legumes, such as *Astragalus*, which may accumulate As, Mo, Se, Zn, and possibly other elements. Our evaluation of the plant analyses indicates that most high concentrations of potentially toxic elements in plants are related either to relatively high uptake from a contaminated substrate or, more commonly, to surface contaminated resulting from wind-borne dust. Most high concentrations are thus not the result of natural accumulation in an uncontaminated area.

Two ill adult tortoises were salvaged from the Rand district and necropsied. One of the two contained the highest level of As (15 mg/kg wet weight) in keratin (scute) recorded to date in necropsied tortoises. The ingestion by tortoises of plants from these mineralized or contaminated areas may thus represent a potential threat to their health and longevity.

Literature Cited

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